Environmental Sensing Potential with Arrays of Boron-Doped Diamond Microdisk Electrodes

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Electrochemical measurements are intrinsically well-suited for environmental analyses, industrial quality control, and biomedical analyses. Indeed, they are potentially capable of fulfilling many of the requirements for field portable systems such as low-power consumption, small size, reduced cost and on-line monitoring. Key technologies include microelectrode arrays, new electrode materials, and high-sensitivity miniaturized electronics.

The present paper is centered around the development of new electrochemical sensors based on thin-film carbon and boron-doped diamond (BDD) microelectrodes arrays, fabricated by planar lithographic techniques. Boron-doped diamond films fabrication is described in reference [i].

Thin-film carbon and BDD electrode materials are particularly suitable for electroanalytical applications due to their wide working potential in aqueous electrolytes, low and stable voltammetric and amperometric background currents, chemical inertness, and long-term response stability. In this article trace metal and organic content monitoring in water using BDD microdisk electrode arrays is described.

The use of microelectrodes for electrochemical analyses holds a number of advantages such as the possibility to perform measurements in low-conducting media thus eliminating the need for stirring during the process. Until now, metals analyses by stripping voltammetry have required a mercury layer on the electrode for pre-concentration of the metal analyte. However, the pressure of increased environmental regulations along with the lack of availability of mercury electrodes have led to the development of mercury-free sensors for trace metal analyses.

Figure 1 compares cyclic voltammograms measured at 100 mV/s on a platinum and diamond electrode in a copper electrolyte without additive (0.24 M $CuSO_4$, 1.8 M H_2SO_4). The working potential window for diamond, up to +2.5 V is considerably wider than the one on platinum where water decomposition occurs at potentials more anodic than +1.5 V. In addition, a much smaller background current density is observed on diamond compared to platinum. The present investigation demonstrates the advantages of boron-doped diamond electrodes for the determination of organics (additives) contained in plating electrolytes and organics in water.

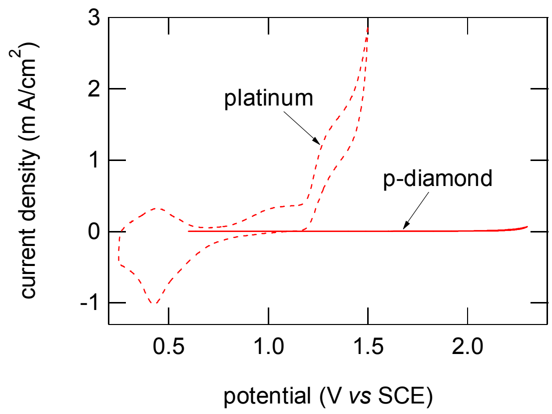

Fig. 1 Voltammograms measured on platinum and boron-doped diamond of a 0.24M $CuSO_4$ / 1.8M H_2SO_4 electrolyte.

By means of an amperometric method reproducible limiting currents can be achieved to detect single organic compounds or sum-parameters like COD for typical environmental water applications.
The variation in the oxidation current for glucose and ethanol at a diamond electrode is plotted in Figure 1 as a function of the chemical oxygen demand (COD). The COD is defined as the amount of oxygen equivalents consumed in the oxidation of the organic compound. The measurement was performed by measuring the current at a potential of +2.15 V in a 0.05 M K_2SO_4 solution containing various glucose and ethanol composition respectively. A linear relationship is obtained for glucose and ethanol concentrations up to 0.2 and 0.06 g/L respectively. The plots of Fig. 1 may be used as a calibration curve to determine glucose and ethanol concentration respectively.

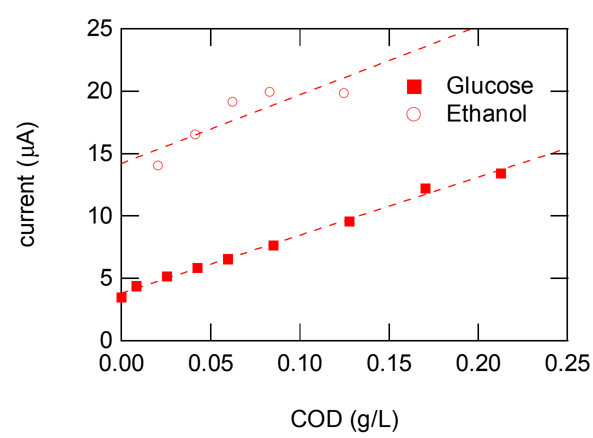

Fig. 1 Amperometric measurements performed on a boron-doped diamond electrode in a 0.05M K_2SO_4 solution containing various glucose and ethanol concentrations.

First results show a promising potential for the development of a new alternative COD analyzing technique in water using diamond electrodes avoiding toxic chemicals.
By virtue of their inherent chemical inertness, durability, low background current and low fouling behavior, BDD microelectrodes have proved stable for on-line monitoring in difficult media, in natural, process, as well as waste waters.

[1] D. Gandini, P.-A. Michaud, I. Duo, E. Mahé, W. Hänni, A. Perret, *New Diamond and Frontier Carbon Technology*, 9,5 (1999) 303